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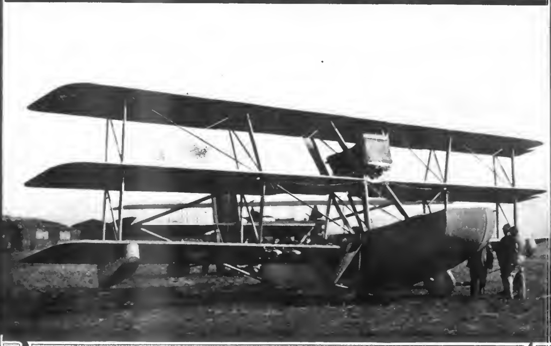

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VOLUME VII
Number 9

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PECULIARITIES IN FLYING IN THE WIND
THE LINKE-HOFFMANN GIANT AIRPLANES
DEVELOPMENT OF A 15-FT. WING RIB
STATIC HEAD TURN INDICATOR FOR AIRPLANES
AIR FANS FOR DRIVING GENERATORS ON AIRPLANES

PUBLISHED SEMI-MONTHLY
BY
THE GARDNER-MOFFAT CO., INC.
HARTFORD BUILDING, UNION SQUARE
22 EAST SEVENTEENTH STREET, NEW YORK

Entered as second-class matter, August 3, 1918, at the
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Cleveland	Washington	Eric Springer	360 Miles	2 hours, 55 min.	14 hours
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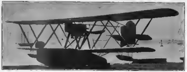

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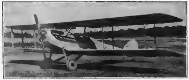

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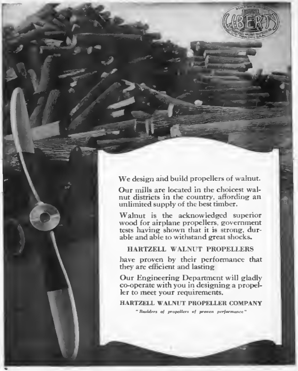

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WASHINGTON OFFICE, EVENING STAR BUILDING

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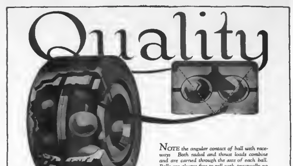

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BUSINESS MANAGER

Vol. VII December 1, 1919 No. 9

IN a recent paper before the Insurance Society, a well known insurance man spoke of the good feeling which insurance people had as a whole towards aeronautics, and the effort they were prepared to put forth to help the industry in its initial stages. They owed it as a public duty, so Mr. Cowles thought, to take up aviation insurance even if the business were meagre and unprofitable

Now while we appreciate the kindliness of these remarks and feel sure that the cooperation of insurance companies would be a valuable help to the industry, we rather resent the patronizing attitude Give the industry just a little more time, and aviation insurance will be a large source of profitable income for the insurance men, and a source constantly growing Instead of patronizing the industry, insurance companies would do better to study the subject intensively, to give a hand in seeing that certain well known precautions in structure and piloting were always observed Their differential action in granting insurance only on certain ships, with well qualified pilots, and to entirely reputable operating companies would be extremely helpful in keeping the industry on an entirely steady basis

British Effort in the Air

News has just arrived of the successful termination of a flight from England to Australia On a route following Paris, Lyons, Rome, Naples, Brindisi, Sicily, Aboukir, Kantara, Damascus, Baghdad, Basra, Karachi, Delhi, Calcutta, Rangoon, Penang, Singapore, Bandoeng, Agambola and Port Darwin, more than half the ports of call are British possessions.

A similar flight might be made from the Cape to Cairo. A huge British flying boat might fly from Ireland to Canada, and be on British territory on both sides of the ocean

There is nothing astonishing therefore that the British people as a whole, and the British Government in particular, should devote such keen attention to aerial work, and devote such large sums to its development

As in the case of the Merchant Marine, the United States will have to meet the mighty yet almost unconscious British effort, with a determined and conscious effort

Cockpit Design

It is interesting to see how rapidly the art of cockpit design is developing

An interesting example is the cockpit of the Sopwith "Wallaby," designed primarily to attempt the Australian flight

The pilot's and navigator's cockpit is fitted with Triplex side windows and a floor window in front of the pilot Normally the seats allow the crew to sit in the usual position with their heads just clear of the cockpit, but provision is made by means of which the cockpit may be converted into an enclosed cabin, the seats being fitted with clips which allow them both to drop about a foot and sliding doors being pulled across the openings. Four of the side windows are made to open, and a pipe running from the front of the radiator supplies fresh air to the crew Dual control is provided, and the pilot has two rudder bars one above the other, for the two seat positions. There is a system of pull-out tables for charts and slots for instruments The circular opening for the pilot's head is fitted with an aluminum beading which is graduated off into degrees for use with a sextant. In rear of the passenger are cupboards for food.

It would seem quite possible even in a small single-engined machine to design a cockpit providing every facility for piloting and navigation, which is thoroughly comfortable and livable

Parachutes

E. R. Calthrop, the well known designer of parachutes, suggests that the worst enemy of the parachute is the presence of projections in rear of the cockpits on which the parachute may run foul. The parachute, however well designed, is always a delicate affair, and even a small rent may cause disaster If the tail skid in particular presented a smooth unbroken outline, there would be much less chance of accidents Mr Calthrop suggests very forcibly that in the design of military machines definite specifications be laid down to remove projections in rear of cockpit, and his suggestion is worth consideration, particularly in view of the authority that his experience warrants

Water Resistant Plywood Glues

In a recent issue of AVIATION, a description is given of tests for waterproof glues developed by the Forest Products Laboratory

To read of the rigid tests now imposed, and successfully met, is most reassuring to the airplane construction. The Forest Products Laboratory considers 8 hour boiling and ten day soaking tests as quite reasonable, with the boiling tests producing more severe damage.

Such tests, it is safe to say, are much more severe than anything that glues will have to withstand in current practice They indicate tremendous progress since the early days of glue manufacture.

Explanation of Peculiarities Observed in Flying in the Wind

By J. G. Coffin

Assistant Director of Research, Curtiss Engineering Corporation

Considerable misconception exists in regard to the effect of wind on machines which float or fly in the air.

The misconception arises principally in not distinguishing between the speed of the machine in the air as compared to the speed of the machine relatively to the ground, and in not having a full realization of the fact that forces are only produced by changes in velocity and not by velocity itself.

A steady wind is detrimental only in so far as it reduces the ground speed when going against it, but it is also of advantage when going with it and as a matter of fact it is of benefit as far as getting off and landing is concerned with heavier than air machines as it reduces by the additional wind speed (at the ground) the getting off and landing speeds.

The getting off and landing ground speed of a plane would be zero if it headed into a wind equal in speed to the slow speed of the plane, thus avoiding the strains on the landing gear due to high relative ground speed.

An airplane flies relatively to the wind, whatever the wind velocity may be. This statement becomes evident when it is remembered that the necessary lift required for flight can only be obtained by a definite relative speed between the plane and the air for any given angle of incidence.

The atmosphere is carried around by the earth at a speed which amounts to about 750 miles per hour in this latitude. To all intents and purposes this is a wind of frightful velocity and yet no one considers it one because we are all moving with it and hence are at rest relatively to it.

What is ordinarily called a wind is a relative motion between the earth and the atmosphere above it. It is felt as a wind because everything, excepting free objects in the air, cannot move with it.

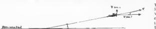


Fig 1

An airplane or balloon as long as it is in contact with the ground is buffeted by the wind, but very soon after it loses contact with the ground it partakes of the general wind motion. Were it not that the pilot can see his drift relatively to the ground, he would not and could not be aware of any wind excepting that produced by his own motion through the air necessary, in the case of the airplane, for sustentation. In the case of a balloon, it is always floating in calm air. These remarks refer to a uniform and steady wind only.

When the wind is unsteady or gusty entirely different phenomena arise. Changes in wind speed, especially abrupt ones, are not only distinctly felt but often produce dangerous disturbances. Changes in wind speed are, however, felt only while the change is taking place and no longer, although their effects may last for a longer period. The speed of the wind before and after the change is of absolutely no consequence, the magnitude of the disturbance depending on the rate of change of wind speed and the duration of this rate of change.

The course of an airplane relatively to the ground can always be obtained by the vectorial addition of the velocity relatively to the air and of the velocity of the air relatively to the ground. In a steady horizontal wind, as far as the plane is concerned, there should be and can be no reason for any peculiarity in its control.

As an apparent exception to this statement it is well to mention that if a pilot judges his air speed by his view of the ground, when flying in a wind, he will be misled and since he may not know the wind speed he may commit serious errors of control especially on landing and in maneuvering. This is, however, purely psychological and is not pertinent to the subject of this paper.

Now, apart from any such explanation, since it is positively asserted that peculiarities of control do occur in a steady wind that do not occur in calm air and that experienced pilots provide for them, the reasons for such provisions must be looked for elsewhere. There are two principal possibilities to consider.

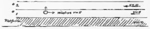


Fig 2.

1st. A vertical wind gradient exists—meaning by this that the horizontal wind speed changes with the height above the earth's surface. This change is usually an increase.

2nd. A more or less periodic horizontal variation in wind speed exists—meaning what are known as "Gusts." Case 2 is not susceptible of easy mathematical treatment[*] and in addition the peculiarities we are attempting to explain occur even when the wind is blowing steadily. We shall then limit ourselves to the consequences of Case 1.

In this case the air is supposed to have different horizontal velocities at different altitudes and the plane must rise or fall in order to experience the effect of any variation of wind velocity. As the pilot is continually changing his level in flight, either consciously or unconsciously when making turns, climbing, gliding, stunting or by uncontrolled changes in propeller thrust he must necessarily be subjected to such variations.

The immediate problem then reduces itself to finding the effect on the rate of climb in a wind which has a velocity increasing (say) with altitude according to some law. It is, of course, well known that at moderate altitudes the wind velocity does increase with height, the observed effect being most naturally ascribed to friction with the earth's surface. The direction of the wind, also, can and does change. Changes in wind speed of 20 m.p.h. per 1000 ft. rise and of over 90° in direction are not unusual. We shall, however, consider that merely a speed change takes place. It is also evident that the speed change per ft. rise can and does vary at different levels, but for purposes of calculation we shall assume that the wind speed increases at a uniform rate per ft. rise.

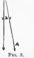
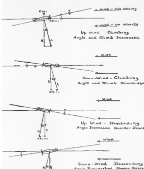


Fig. 3.

Effect of a Wind Gradient

Consider an airplane climbing with speed V along its flight path, this path making an angle i with the horizontal. Assume that the wind speed increases at a rate of "n" feet per second per ft. rise. The quantity "n" is called the vertical wind gradient.

The vertical speed of the machine is $V \sin i$ ft./sec . . . . (1)
and hence the increase in wind speed per second due to the vertical rise is $n V \sin i$ ft./sec^2. . . . . (2)
This last expression is the acceleration in wind velocity due to a rise. This acceleration acts on the plane just as if the plane, flying originally in calm air, were to experience an increase in wind speed. It is evident that if it were facing this extra wind the result would be an improved lift, and if it were facing the other way the lift would be decreased.



Figs 4-5-6-7

There results, in other words, an apparent horizontal acceleration of the plane, which is in the *direction opposite* to the wind velocity when the plane is going from low speed wind into higher speed wind and which is in the *same direction* as the wind when going from high speed wind into lower speed wind.

This matter which is fundamental can perhaps be more easily understood by the following analogy.

Consider a number of moving platforms, Fig. 2, such as have been proposed at various time for subway transportation. Let the platforms be three feet wide and each one have a speed of 5 ft./sec greater than the preceding one. As it is comparatively easy to step from the ground onto platform 1, it will be subsequently just as easy to step from 1 onto 2 and so on until finally the pedestrian finds himself on a platform moving at a comparatively high speed. There is an increase of 5 ft./sec. for every 3 ft. of motion across the platforms, *or 5 ft./sec. per 3 ft. = ft./sec. per ft.*, which number corresponds to the quantity "n" in equation (2).

If, now, one were to run around, back and forth over such a system of moving platforms it is quite evident, and would be more so on trial, that "things" are peculiar. It is just such peculiarities that a plane experiences in maneuvering in a wind which has a wind gradient.

Consider now what happens when a *heavy* ball is rolled across the platforms. As soon as it rolls onto platform 1 it finds the platform coming towards it at a speed of 5 ft./sec. (on account of its inertia it is not immediately carried along by the platform), or, what is the same thing, its speed has been increased in the direction opposite to the motion of the platform by this same amount. If it rolls across the platforms at the rate of 3 ft./sec we can say that the ball receives an acceleration relatively to the platform, where it is at any instant, of 5 ft./sec.^{2}. This is the kind of quantity represented by (2). The direction of this acceleration is opposite to the motion of the platform.

Consider what would happen to yourself in stepping from one platform to the next one moving faster. Unless you especially prepared yourself you would fall sideways, your head pointing in the direction opposite to the motion of the platform. In other words, when you stepped across the line you received the equivalent of an impulse on your body directed up-platform since you fell with your head pointing in that direction. It is an impulse because the change in speed is sudden. If there were six platforms one-half foot wide instead of one 3 feet wide in every 3 feet, each moving 5/6 ft./sec. faster than the preceding one, this impulse would become more nearly a uniformly acting force.

Now, as long as an airplane headed against the wind rises into wind of greater velocity it is acted upon by such a force and consequently flies at a greater speed than usual. The lift is increased and remains increased as long as the plane rises into faster moving air and the climb is improved.

On the other hand, converse phenomena take place when a body goes from a rapidly moving platform to a slower moving one. The accelerations are all reversed.

Besides the acceleration just described which acts on the plane, there is the acceleration of gravity. These two accelerations combine into one resultant of amount—

$$A = \sqrt{g^2 + \overline{nV \sin i}^{\,2}} \qquad \text{. . . . . (3)}$$

which makes an angle

$$b = \tan^{-1} \frac{nV \sin i}{g} \qquad \text{. . . . . (4)}$$

with the vertical.

The plane flies relatively to this resultant acceleration A just as it flew previously in calm air with respect to the acceleration of gravity g.

If it can climb at an angle $i + 90$ with respect to the vertical (g), it can climb at this same angle (very approximately) with respect to A which to all intents and purposes becomes the new relative vertical.

Figures 4, 5, 6 and 7 show the direction of the resultant vector accelerations for a plane climbing up-wind, a plane climbing down-wind, a plane descending up-wind and a plane descending down-wind respectively—up-wind meaning flying against the wind, down-wind, flying with the wind.

Fig. 4. Climbing against the wind: The plane goes into faster moving air. The angle i is increased by the angle h, and the plane climbs better.

Fig. 5. Climbing with the wind: The plane goes into faster moving air. The angle i is diminished by h and the plane does not climb so well.

Fig. 6. Descending against the wind: The plane goes into slower moving air. The angle i is increased by h and the plane descends at a steeper angle.

Fig. 7. Descending with the wind: The plane goes into slower moving air. The angle of descent i is decreased by h and the plane descends at a lesser angle.

Consider Cases 4 and 6. A pilot starts to climb, the plane is lively and climbs rapidly, the lift is increased. He starts to glide down, the plane descends rapidly, it has lost in lift and seems to fall.

Compare Cases 5 and 7. A pilot starts to climb; the plane acts sluggish and climbs badly, the lift is diminished. He starts to descend, the plane tends to fly horizontally and he depresses the elevator in order to descend more rapidly.

---

[*] In regard to this see work of E. B. Wilson, Theory of an Airplane Encountering Gusts. Part I—First Annual Report of the National Advisory Committee for Aeronautics, 1915, pp. 82-75; Part II—Third Annual Report of the National Advisory Committee for Aeronautics, 1917, pp. 409-443.

Suppose now while descending he has spiraled and is now headed into the wind Case 8 comes into effect and the pilot to his surprise descends at a perhaps alarming angle.

It must already be quite evident that the machine would seem to act queerly to a pilot unaware of the reasons for such behavior

Effects to Be Expected on a Turn

Suppose that a plane flying horizontally up-wind makes a turn, either to the right or to the left, of 180° in order to fly down-wind The turn produces a drop, hence the plane goes from horizontal flight up-wind, normal condition, into Case 7. The usual drop is minimized.

A plane flying horizontally down-wind, normal condition, makes a 180° turn in order to fly up-wind A turn produces a drop, hence the plane goes from normal flight into Case 6 The usual drop is accentuated

When the first 90° of a turn has taken place a corresponding drop has also taken place and the plane gets a sidewise acceleration which produces an effect similar to a side gust on a plane flying normally

If originally flying up-wind, a 90° turn produces the equivalent of an up-wind gust

If flying originally down-wind a 90° turn produces an up-wind gust.

Numerical Results

Referring to equation (4) defining b as the change in the angle i as small we can take this small angle to be the same as its tangent, the angle i is also small and no serious error is committed in using it directly instead of its sine

Since then exactly

$$\tan b = \frac{a V \sin i}{g}$$

we can write approximately

$$b = \frac{a V i}{g}$$

and, therefore,

$$\frac{b}{i} = \frac{a V}{g}$$

which is the fractional change in climbing angle due to wind gradient a

If a is in m.p.h. per 1000 ft.
V is in m.p.h
and g is 32.2 $ft./sec.^2$, we may write this expression as

$$b/i = a V\ 0.0067\%$$

For example, if the wind increases at the rate of 20 m.p.h. per 1000 ft and the plane is travelling at the rate of 100 m.p.h., the percentage change between climb up wind and climb down-wind is a decrease of

$$2 \times 20 \times 100 \times .0067\% = 26.8\%$$

The difference in climb up wind and climb in calm air for the same conditions is 13.4%. If the plane travels at 150 m.p.h. under the same conditions the percentage change becomes 20% instead of 13% and 40% instead of 26.8% In other words, a certain fraction of the wind energy can be utilized in this manner

If it be assumed that the wind has periodic increases and decreases in horizontal speed at any given level it is seen from the foregoing that by proper maneuvering its energy can be drawn on to partially sustain the machine. The great practical drawback, however, is that the pilot can only be aware of these changes by the "feel" of the plane and could only utilize them after long experience, if at all. Birds probably are instinctively able to adapt their flying attitude to these varying conditions and have the advantage also of the fact that small sized gusts can be utilized whereas with a large airplane it would require that the cross section of the disturbance be as large or larger than the airplane

Forces and Moments Brought Into Play on Banking

There are still other actions taking place while making a turn in a wind in which there exists a wind gradient

Consider an airplane flying against the wind which banks while making a 90° turn to fly across the wind.

Since the right hand wing rises and the left hand wing descends, the former is acted upon by an increased speed of down-wind and the lower by an increased speed of up-wind.

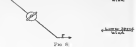


Fig 8

As seen in the diagram, this produces an upsetting couple FF' tending to increase the bank and sharpen the turn

After the next turn of 90° to fly with the wind this couple disappears and two others make their appearance: one due to unequal drifts on the right and left wings, the drift being less on the higher and greater on the lower, which couple tends to yaw the machine slightly to the pilot's left, and the other due to unequal lift on the right and left wings, the lift on the upper being decreased and on the lower increased relatively. This couple tends to under bank the machine and is a righting couple.

Consider an airplane flying with the wind which banks while making a turn to fly across the wind.

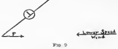


Fig 9

This maneuver brings into existence a couple FF' tending to right the machine and widen the turn

After the next turn of 90° to fly against the wind this couple ceases to exist and, as before, two new couples appear One due to unequal drift tending to yaw the machine towards the pilot's right and the other due to unequal lift which is greater on the higher than on the lower wing, which is therefore an upsetting couple and tends to make the turn sharp

The resultant effect as felt by the pilot is made up of these various separately described effects. There is, however, no question in one mind but that these effects produce the peculiarities felt by all pilots when maneuvering in the wind

It should also be noticed that the relative value of these effects changes with the size and weight of the machine being flown

Rough calculations were made of the magnitude of these couples for a machine of 40 ft. span, aspect ratio 6, weighing 3,000 pounds for a 20 m. p. h. per 1,000 ft. and an angle of bank of 45°.

The cross wind couple is negligible. The couple due to unequal lift gives a value of about 150 lb.-ft. The yawing couple due to unequal drift about 15 lb.-ft.

Bumps and Air Holes

The shocks which are nearly always felt in a machine in flight are somewhat of the same nature as the effect of unevenesses of a road on an automobile and are probably due to sudden small changes in wind speed or wind direction, or both

As a slight change in vertical wind direction seriously modifies the lift it is easily understood that a sudden drop or rise will tend to take place, and as soon as the plane passes through the disturbance it regains the even tenor of its way

The so-called holes in the air are easily explained as the result of the meeting by the plane of a fairly large area in which there is either a sudden shifting of the vertical wind direction downward, producing not only a drop due to the downward component of the wind velocity, but also a decrease in lift due to the greatly decreased angle of incidence, the two combining into a sudden and alarming drop, or a sudden change in air temperature, thus producing a corresponding change in air density and causing a sudden change in lift. This is a decrease if the temperature change is a rise These two reasons can also act simultaneously.

From the foregoing discussion it should now be realized that a thorough understanding by the pilot of the possible causes of peculiarities is absolutely necessary. This understanding is as necessary for the air pilot as it is for a car driver to know, for instance, that a car is liable to skid on a turn or that wet pavements are liable to be slippery The knowledge of these causes gives him a realization of what is occurring and the reasons therefore, as well as indicating the proper maneuvers for overcoming their detrimental effects and utilizing them for his advantage

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Halford Aero Motor

The Auto Motor Repairing Co., of Brooklyn, announces the completion of the Halford Aero Motor, and gives the following brief particulars

Standard Bore—
Ignition—Atwater-Kent,
Carburetor, Zenith;
Maximum speed, 1500 r.p.m
Suited for a 6 ft 6 in propeller with 3 ft. pitch.
Special Bore—
Bosch magneto ignition;
Zenith carburetor,
Special oversized valves,
Forced feed lubrication,
Zepher pistons,
Special leak-proof piston rings,
Extra large carburetor,
R.P.M. up to 2000
Suited for a propeller of 4 ft. to 5 ft. pitch

The motor is a modified Ford motor which is expected to stand up well in aviation practice

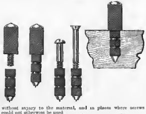
Car of the U S Navy O-1
(C) International

U. S Navy O-1, Purchased from the Italian Government
(C) International

Stine Screw Holes

Stine Screw Holes have been designed to meet a need that has long been felt in wood construction They are made to fit all sizes of screws After they are hammered in, the head is removed, leaving a permanent screw hole. Besides this simplicity, whereby any one able to drive a nail is able to drive in a screw hole, it has also the qualities of neatness, durability and convenience.

The Stine Screw Hole is made of brass, and will therefore not rust under atmospheric conditions Holes can be driven without injury to the material, and in places where screws could not otherwise be used



With special reference to the airplane construction, Stine Screw Holes may be useful in the following ways:

1. In the attachment of instruments to the instrument board.
2. In removable floor board and at points where removable seats are attached to the structural members of the fuselage
3. For such control attachments as are necessary to dissemble when planes are taken down for shipping
4. In securing removable sides of the costly cases in which planes are packed and shipped.

Development of a 15-Foot Airplane Wing Rib

By Raymond M. Wirka*

During the progress of the war the Forest Products Laboratory of the United States Forest Service, Madison, Wis., at the request of the Aircraft Division, Bureau of Construction and Repair, Navy Department, undertook the development of an airplane wing rib of minimum weight, having a chord length of 15 feet, and capable of sustaining, without rupture, a distributed load of 670 pounds.

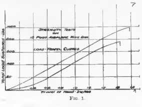


Fig. 1

Two distinct forms of rib were investigated at the laboratory as possibilities for development, namely, one having a plywood web, the other using some form of truss to carry the load. In the former type the web section was made of three-ply wood with adjacent plies glued at 90 degrees to each other; in the latter, various truss designs were tested.

Method of Test

Ribs for each design were tested under high-speed load distribution, and a few ribs of the final design were also tested under low-speed load distribution. The distribution diagrams shown in Fig. 2 were used.

Ordinates of both diagrams represent the sum of the unit lift pressures on the upper and lower wing surfaces. The apparatus used for applying load to the ribs is shown in Fig. 10. By dividing the bases of the diagrams (Fig. 2) into 16 equal distances and extending vertical lines upward, each diagram is divided into 16 areas. The 16 concentrated forces applied to the rib are proportional, respectively, to the 16 areas into which each diagram is divided. The downward motion of the movable head of the machine causes the load to be applied to the rib. To approximate the lateral stiffening the rib receives from the wing covering when in service in the airplane, the top and bottom flanges were fastened, by means of cords, to beams paralleling the rib and bolted to the testing machine.

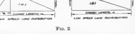
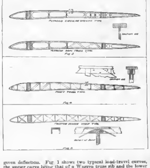


Fig. 2

Comparison of Ribs

All ribs tested were compared for total load sustained, weight, stiffness, and specific strength; that is, the ratio of the total load sustained in pounds to the weight of the rib in ounces. Another factor considered was adaptability to production. The values obtained from the different types of ribs tested are given in the tables of Figs. 11 and 12.

To determine the relative stiffness of the various types of ribs tested, the load sustained by the rib was plotted against the travel of the movable head of the testing machine. The stiffness of the rib is proportional to the load sustained at a given deflection. Fig. 1 shows two typical load-travel curves, the upper curve being that of a Warren truss rib and the lower that of a twisted-veneer rib. The lower curve lacks stiffness at low loads probably because of initial slackness in the veneer tension members. The upper curve shows the effect of more rigid construction.



Besides stiffness, the curves show the total load sustained. The work necessary to cause failure can be determined by the integration of the area under the curve.

To obtain maximum efficiency from the wings when in flight it is considered desirable that the aerofoil change as little as possible. That is to say, other things being equal, the rib showing highest stiffness is the best.

Description of Ribs

Seven types of ribs involving 13 different designs were tested: plywood, wrapped veneer strap, twisted veneer strap, modified Navy design, Pratt truss, Warren truss, and double Pratt truss. A key to these various ribs is given in the following tabulation:

KEY TO FIGURES

Design No.	Type.	Strength Values, Weights, Dimension, etc. Fig. No.	Details of Construction Fig. No.
	Plywood circular opening		3
	Plywood semi-truss		3
1	Wrapped veneer strap	11	
2	Wrapped veneer strap	11	
3	Wrapped veneer strap	11	9
4	Twisted veneer strap	11	5
5	Navy design (modified)	11	6
6	Pratt truss	12	4
7	Warren truss	12	7 Part a
8	Warren truss	12	7-Part a
9	Warren truss	12	7 Part b
10	Double Pratt truss	12	8
11	Warren truss	12	7-Part b

Discussion of Results

Plywood Web Ribs.—In the development of ribs of chord lengths from 55 to 96 inches favorable results were obtained by using 3-ply wood webs having the face grain vertical and the core grain horizontal. The first of the 15-foot ribs to be tested was of this type, the faces of the plywood web being of 1/32-inch birch and the core of 1/16-inch Spanish cedar. Two types, the circular opening and semi-truss, Fig. 3, were used. These ribs failed by bending of the plywood between openings and by buckling of the web near the upper and lower cap strips.

An attempt was made to strengthen the rib for column action by glueing vertical battens to both sides of the web between openings, and to increase the resistance to buckling by glueing horizontal strips to both sides of the web near the upper and lower cap strips. The addition of this stiffening increased the weight of the rib considerably, without materially increasing the load sustained. Reinforced in this way the ribs weighed on the average about 2.5 pounds and sustained a load of about 250 pounds. These ribs were tested with the load distribution of Fig. 2-a.

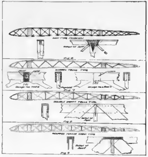
While a plywood web rib could have been developed which would sustain the 670 pounds desired, previous tests on ribs of this kind indicated that such a rib would weigh considerably more than 3 pounds. The use of some form of built-up truss construction was therefore deemed necessary if a sufficiently light rib were to be obtained.

Wrapped Veneer Strap Rib.—In the wrapped veneer strap design, Nos. 1, 2 and 3, Fig. 11, an attempt was made to utilize the full tensile strength of the veneer tension members which extend the length of the rib and are wrapped as shown in Fig. 6. By the addition of channels in design Nos. 2 and 3 satisfactory strength was obtained, although the strength weight ratio was below that of some of the other types tested.

Twisted Veneer Strap Rib.—The twisted veneer strap ribs, No. 4, Fig. 5, failed repeatedly in the tension members at the lower cap strips near the front and rear spars. Better steaming of the diagonals before bending would probably have improved the strength somewhat although it is doubtful whether or not the strength values would have equalled those of other ribs tested. This rib was, further, not so stiff as some of the other ribs tested.

Modified Navy Design Rib.—Design No. 5 designated as the Navy design (modified) gave very satisfactory values of strength, weight, and specific strength, but required considerably more time in construction than some of the other ribs having equally good strength and weight values.

Pratt Truss Rib.—From previous tests on commercial 10-foot wing ribs of the Pratt truss type it was found that the strength of the joint between the diagonals and the cap pieces was almost wholly dependent upon the glue, the screws contributing little to the strength of the joint. Because of failure in the glue the full tensile strength of the diagonals was not obtained. All diagonals of ribs of design No. 6, Fig. 12, were made of single-ply veneer to increase the area of the glued surface between diagonals and web strips. The strength and weight values of these ribs were very satisfactory and the ribs are very simple to construct.



Double Pratt Truss Rib.—The double Pratt truss ribs, design No. 10, are somewhat similar to those of design No. 6, and are suitable for reverse loading. The results obtained from tests on these ribs were not as satisfactory as those on ribs of the Pratt truss.

Warren Truss Rib.—Of the various designs of Warren truss ribs, design No. 11 proved to be the most satisfactory. All component members were made of spruce. The ribs are suitable for reverse loading, assuming the same load distribution.

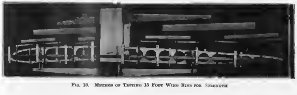


Fig. 10. Method of Testing 15 Foot Wing Ribs for Strength

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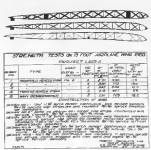
* Assistant Engineer in Forest Products, Forest Products Laboratory, U. S. Forest Service, Madison, Wis.

Conclusions

The load-travel curves of the plywood web, twisted veneer strap, and Pratt truss types showed that ribs of of these types were not quite as stiff as those of the other types

Although plywood proved very satisfactory for webs of ribs of short chord lengths, the development of 15-foot wing ribs has shown quite conclusively that a plywood web construction is impractical for ribs of this length.

Ribs of the Warren truss type, design No. 11, were superior in strength per unit weight to all other ribs tested These ribs are partially dependent on glued surfaces for strength, they possess considerable residual strength due to the tapped and taped construction Should failure occur because of poor gluing, however, they embody many of the desirable features of airplane wing ribs—high strength per unit weight, stiffness and simplicity of design—and possess, in addition, considerable strength in reverse loading



STRENGTH TESTS ON 15 FOOT AIRPLANE WING RIBS

PROJECT L225 2

DESIGN NO.	TYPE	LOAD DISTRI-BUTION	NO OF TESTS	W-AV. WEIGHT OF RIBS	P AV. TOTAL LOAD SUSTAINED LB.	RATIO P/W
1	WRAPPED VENEER STRAP	FIG. 2	3	2.70	435	115
2	" " "	"	2	3.80	772	134
3	" " "	"	2	3.43	634	185
4	TWISTED VENEER STRAP		3	3.16	447	58
5	NAVY DESIGN (MODIFIED)		3	2.81	729	18.2

CONSTRUCTION OF RIBS

FOREST PRODUCTS LAB
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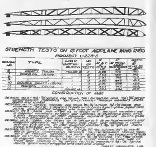
Fig 11



STRENGTH TESTS ON 15 FOOT AIRPLANE WING RIBS

PROJECT L-225-2

CONSTRUCTION OF RIBS

FOREST PRODUCTS LAB
U.S. DEPT OF AGRICULTURE

Fig 12

Note on the Effect of Water Vapor in Hydrogen Upon the Lifting Power of the Gas

In connection with the discussion of the purity of hydrogen it is interesting to note the effect of water vapor upon the lifting power of hydrogen The specific gravities of hydrogen and water vapor are 0 0695 and 0 622. The reduction in lifting power of hydrogen when saturated with water vapor at different temperatures is shown by Fig 1

If hydrogen is compressed in cylinders and the cylinders contain some water in the liquid form, then the hydrogen will be saturated with water vapor at the temperature of the cylinder and each volume of the high-pressure hydrogen will contain the same volume of water vapor as it would if under a pressure of one atmosphere and at the same temperature, hence when it is withdrawn from the cylinder and expanded to the lower pressure it contains only a relatively small amount of water vapor per unit volume The gas is, therefore, comparatively dry if it has been expanded from a high pressure The magnitude of the loss in lifting power at one temperature (30° C) and different pressures is shown in Fig 2. The data in Fig. 2 are computed on the assumption that the gas will be expanded from the high pressure to atmospheric pressure without either mechanical entrainment of liquid water that may be in the high-pressure container or absorption of water vapor from this liquid during the period of expansion of the gas

In considering the advantages of using dry hydrogen for inflating balloons the fact should not be overlooked that rubberized balloon fabrics are somewhat permeable to water vapor. Therefore, even though the gas is put into the balloon dry it will become partially saturated with water vapor which penetrates the fabric and will ultimately approximate the moisture condition of the surrounding atmosphere

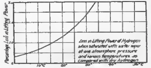


Fig 1. Temperature

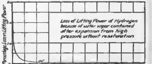


Fig. 2. Gage Pressure—Pounds

The Static Head Turn Indicator for Airplanes*

By Sir Horace Darwin, K.B.E., F.R.S.

An instrument to indicate whether, under all conditions, the path of the airplane is a straight line or whether it is turning to the right or left is much required It is well known that when flying in a cloud or at night, and no fixed object is visible, even the most experienced pilot may, without realizing it, be flying on a sharp curve. If, however, the angle of banking is great the muscular reaction of his body will have to be increased to counteract the increased force acting on it This will tell him that his course is not straight, but there is nothing to show whether he is on a right-hand or left-hand turn. If he tries to straighten his course he is just as likely to increase the curvature as to straighten out. If he observes his compass he will probably find that it is swinging so much that it will tell him something is wrong, but give no guide to what he should do.

A turn indicator enables a straight compass course to be kept when flying in clouds or at night, and this is valuable for long-distance flights. But straight flying is always important. If the clouds are low and the airplane leaves their lower surface when on a sharp turn there may not be sufficient time to allow the machine to be put into a safe position for landing before the ground is reached

Successful turn indicators using gyroscopes have been made. With the static head turn indicator, in conjunction with a good airplane compass and a cross level, a true compass course can be kept in clouds or at night. The success of this instrument is due to the large amount of experimental work done at Orfordness and at the Royal Aircraft Establishment, and to the design of the Ogilvie pressure gauge manufactured by the British Wright Co. Unless a pressure gauge as good and as sensitive as this instrument had been designed, the turn indicator would not have been a success.

A great number of experiments had to be tried in order to determine the best position for fixing the static heads, on the relative advantages of fixed and swivelling static heads, and on the effect of side-slip.

A sensitive differential manometer is fixed on the instrument board, and the Ogilvie pressure gauge is used for this purpose. The two openings from it are connected to two static heads, fixed to the wings as far apart as can conveniently be arranged, and in a position so that the air pressure at these points is influenced as little as possible by the wings or body of the airplane The manometer will then indicate a difference of pressure when the airplane is turning The hand will move in one direction for a turn to the right and in the other direction for a turn to the left

The pressure gauge was designed by the British Wright Co. for use with the turn indicator, and is of the Ogilvie type An extremely sensitive circular rubber diaphragm separates two chambers in the instrument. These chambers are connected, one to each static head, and the minute difference of pressures caused by the airplane turning deflects the diaphragm by a small amount. The deflection is communicated directly by a silk thread, without intermediate gear, to the indicating hand and moves it to the right or the left The scale carrying the zero mark and divisions is adjustable by the pilot during flight by the use of one thumb, and he can easily set the scale in the correct position when flying on a straight course immediately after leaving the ground. This adjustment is most desirable, as it is found that the position of the hand when on a straight course does not correspond with absolute equality of pressure on the two sides of the diaphragm.

This is due both because it is impossible to make both static heads absolutely similar, and also because the actual static pressure at the two positions where the static heads are fixed are not equal No doubt if it were possible to fix the static heads at a great distance in front of the wings the amount of adjustment required would be greatly reduced. The adjustment required is seldom more than 10 deg

The air inside the static openings is very nearly the true air pressure outside in a well-designed static opening The static heads used are the same in form as those used in the standard air-speed indicator The tube moves through the air in the direction of its axis, the stream-line end of the tube disturbs the air as little as possible, and thus the air passes over the holes in the side of the tube at right angles to their direction. It had been found by experiment that the air pressure inside the tube is very nearly the true pressure outside, whatever the velocity the tube moves through the air may be

A great authority on birds tells me that he has no doubt that birds breathe through their nostrils. He might find it difficult to actually prove this, but it is very unlikely that he is not correct It is an interesting fact that the nostrils of birds fulfil to some extent the conditions of a well-designed static opening, the nostrils are holes in the beak, and in flight the beak moves through the air point forwards. It is clear that this arrangement is advantageous to the bird. To ensure ease in breathing, the air inside the lungs should be at the same pressure as the air outside I do not know whether men in airplanes find any difficulty in breathing when the head is in the wind If they do, no doubt the difficulty could be reduced by breathing through properly constructed static openings

Experiments were tried with fixed static heads, as it was hoped that the swivelling form was not necessary They were fixed to the struts between the wings, but in this position side-slipping had a considerable effect, in some cases this was so great that the index of the pressure gauge showed a right-hand turn when a left-hand turn was taken The fixed static heads were then placed in front and above the leading edge of the upper wing In this position the results were much better, but the heads must be truly parallel In this exposed position it was found that they were liable to become accidentally displaced, and as this might easily happen without the pilot knowing it, then the instrument would not be trustworthy When swivelling heads are used and placed in the standard position the effect of side-slip is greatly reduced and turns to the right or left are correctly indicated To eliminate all effect of side-slip the static heads must be put inconveniently far from the wings

The swivelling static heads are required to adjust their angle with the greatest freedom. They are carried by swivelling bearings allowing universal movement and fixed to rigid standards The air is always free to flow by way of a rubber tube, which twists to accommodate the adjustment of the head to right and left and bends to permit of inclination up and down. The static head, thus free to move in all directions, is maintained parallel to the direction of the wind by means of a conical vane. Its weight has no tendency to move it out of the true direction, as it is carefully balanced about its swivelling bearings

It was also found important to avoid sharp bends or constrictions in the tube, as otherwise the indicating on the dial was sluggish. The air tube on the static head openings becoming blocked with ice is a possible cause of failure.

In order to make the action clear, we will assume that the airplane is moving in a circle, that it is not banked, and that the air tube connecting the static heads is horizontal and points along a radius of the circle. The forces acting on the air in this tube are

1 Gravity acting vertically downwards. As the tube is horizontal, this will cause no difference of pressure at the manometer or cause any tendency of the air to move along the tube.

2 The atmospheric pressure at the static heads As the tube is horizontal the pressures at the ends of the tube are equal and in opposite directions, and no effect is produced on the manometer.

3. The pressure of the inner surface of the tube against the air, this clearly has no effect on the manometer

4. Centrifugal force is the one remaining force which can cause a movement of the differential manometer The air will tend to move along the tube in an outward direction and can

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* Abstract of paper read before the Royal Aeronautical Society at the Royal Society of Arts on Wednesday, Oct. 29, 1919

only be prevented from so doing by a difference of pressure on the two sides of the diaphragms in the manometer. It is this difference of pressure which is indicated on the manometer and shows a right or left-hand turn.

All turns, however, are banked, and this assumption is only made to make the action clear.

Let us now consider a banked turn and assume that the aeroplane is banked at the correct angle. By the correct angle is meant an angle which causes no side-slip, that is, such an angle that the apparent direction of gravity (that is the resultant of gravity and centrifugal force) is at right angles to the plane of the wings.

Again consider the forces acting on the air in the tube

1 As the banking is at the correct angle, the resultant of gravity and centrifugal force act at right angles to the direction of the tube and have no effect.

2. The pressure against the inside of the tube clearly has no effect

3. The atmospheric pressure at the two static heads is not equal, as the airplane is banked, the outer end is higher up and at a place where the air is at a less pressure The differential manometer will show this difference of pressure.

Or we can consider this last case differently. The forces acting on the air in the tube are

1 Gravity acting on the air in the tube. As the tube is banked, this will tend to make the air flow inwards

2. Atmospheric pressure at the static heads. As the pressure at the outer end is less than at the inner end, these pressures will tend to make the air flow outwards. The tendency of (1) and (2) are obviously equal and in opposite directions, and the combination of the two will have no effect.

3 The pressure against the inside of the tube clearly has no effect.

4 Centrifugal force is the only remaining force, and this clearly will cause a difference of pressure on the two sides of the diaphragm of the manometer Although these two ways of considering the forces which act on the air in the tube are so different they are both correct

If V = the speed of the aeroplane.
r = radius of the circle in which it is flying
b = the distance between the static heads.
ρ = the density of the air
P = the differential pressure on the air required to prevent its movement along the air tube.
β = the angle of banking

With horizontal flight, no side-slip and the air tube in the vertical plane passing through the centre of the circle

$$P = V^2 \rho b \cos \beta / r$$

Usually β is the correct banking angle, then $\tan B = V^2 gr$ In order to make P large, b must be large As the density of the air becomes less with increased height the indications will also become less.

The instrument can only be used for measuring r if we know the speed and the density of the air, but it is not wanted for this, and is only useful for showing that the airplane is turning to the right or the left.

If an airplane is flying near the ground at 80 m.p.h. in a circle of one mile radius, a complete circle would be flown in 4½ mins., and the correct banking angle would be 4°—40′. If the static heads are 30 ft. apart the air pressure in the manometer would be about 1 mm. head of water when flying near the ground. This pressure will move the hand on the dial through about 14 deg or about 1½ divisions, and the turn will be clearly shown If the height of the airplane is so great that the density of the air is reduced to half its normal amount the indication will also be reduced to one-half

The turn indicator has been tried on many different types of airplanes. The following are some extracts from a report which we have been kindly allowed to see and quote

"In connection with the daily cloud and horizon observations, it has been necessary to attempt to fly through thick layers of cloud. This has been tried on several types of scouts and after considerable practice it was found possible to get through several thousand feet of solid cloud, but it required very rigid concentration on the control of the machine, even then it frequently got out of control and after losing height, climbing had to begin again. It was practically impossible to have any sense of direction during a long climb in cloud. Layers of cloud of various thicknesses up to 6,000 ft. were got through, but it was decidedly unpleasant flying"

The turn indicator was then fixed to a 110-h. p Le Rhone Camel, a difficult scout to fly through clouds. The first position of the static heads was not found satisfactory A second position was tried The report goes on

"Although not extremely sensitive, it was most useful, enabling the machine to be flown in comfort for a considerable time in clouds. . . . As compared with the experience in clouds on scouts without turn indicators, flying in clouds was now quite pleasant, as the machine never showed any sign of getting out of control To fly straight was quite easy, keeping a fairly reasonable compass course, to make a gentle spiral up or down, or a very steep spiral . . .

"The static heads were only tried in two positions, but it may be that a position could be found without their being unreasonably far in front of the plane, so that the indicator would be more sensitive.

"It would need some considerable practice before the average pilot could take a Camel or most scouts through much cloud, but it makes cloud flying on scouts possible, whereas without turn indicators it is practically impossible."

JUNKER FIREPROOF ALL METAL PASSENGER AIRPLANE. THIS MONOPLANE IS REPORTED TO HAVE A SPEED OF 110 M.P.H. ANOTHER VIEW OF THIS MACHINE WAS SHOWN IN THE LAST ISSUE

(C) *Wide World Photos*

The Linke-Hoffman Central Power Plant Giant Biplanes

By Eric Hildesheim

Some detailed information is now available of the giant airplanes built by the German Linke-Hoffman works, embodying a central multiple engine power plant with a single or twin tractors.

The LHR1

It appears that the first Linke-Hoffman model (LHR1), shown in Fig. 1, was of an unsuccessful character The typical Roland contruction was followed here in the design of a body occupying the entire gap from wing to wing. Experiments in the Gottingen wind tunnel indicated increase of aerodynamic efficiency, but in practice the lateral control proved very slow, and pilots could not seemingly judge landing distances in the totally enclosed body. A good point in the design of the machine was the mounting of the tractor screws independently of the wing structure. Most accidents experienced with the Zeppelin Staaken, with engine mounting supported by the wings, were due to stripping of gears, and failure of engine mountings, leading to destruction of the wings themselves.

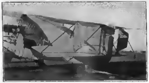


FIG 1. REAR VIEW FIRST EXPERIMENTAL LINKE-HOFFMAN

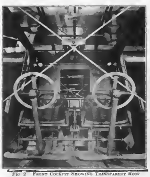
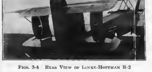


FIG 2 FRONT COCKPIT SHOWING TRANSPARENT ROOF



FIGS. 3-4 REAR VIEW OF LINKE-HOFFMAN R-2

Figure 2 shows a good view of the front cockpit in the nose of the enclosed fuselage of the LHR1 and the transparent roof is clearly indicated

The LHR2

In the LHR2, which was decidedly more successful than the LHR1, there were a number of important modifications. Fig. 3 indicates how closely this later model resembles an ordinary biplane in its general lines, and Fig 4 gives an excellent rear view of this machine It is interesting to compare the main dimensions and the performance of the two models

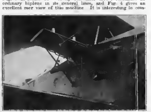


FIG. 5. ENGINE VENTS, EXHAUST PIPES, RADIATOR

	LHR1	LHR2
Span	38.2 metres	42.1 metres
Overall length	15.6 metres	20.3 metres
Height	6.7 metres	7.1 metres
Total wing area	265 sq metres	320 sq metres
Power Plant	4-260 HP Mercedes	4-260 HP Mercedes
Weight Empty	8 tons	8 tons
Useful load (including fuel)	3.2 tons	4 tons
Total load	11.2 tons	12 tons
Maximum speed	130 kilometres pr hr	130 kilometres pr hr
Climb	3000 metres in 2 hrs.	3000 metres in 2 hrs.

While the LHR2 retained the power plant and trans-

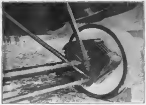


Fig 6. Spiral Spring Shock Absorbers

mission system of the LHR1, it embodied many new ideas, the outstanding feature being the use of a single tractor screw and the general resemblance to an ordinary tractor biplane

Even the two-wheeled landing gear of Fig 6 is nothing but an enlarged edition of ordinary airplane practice. It is claimed and not without likelihood, that the large size of the wheels enables them to pass over ditches without danger of the aircraft overturning A winter test is quoted by the Germans, when to avoid landing in snow on the aerodrome the plane passed on to a neighboring marsh, where two ditches were passed without overturning, the plane finally coming to rest with the wheels embedded 12 in in the marsh Fig 6 shows the very logical provision of the side shock absorber. The straits to which the Germans were driven for lack of material is indicated by the use of steel spiral springs in lieu of rubber shock absorbers, and by the use of wooden tires.

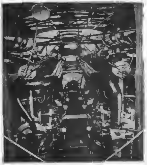


Fig 7. Engine and Gravity Tank Mounting

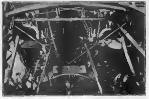


Fig 8. Engine Arrangement, Showing Gears and Clutch

It will be noted that the somewhat peculiar construction of the tail surfaces of the LHR1, with a monoplane stabilizer and double elevator, has been replaced by the biplane stabilizer and elevator in the LHR2

The rear part of the fuselage has a transparent covering to enable ready inspection of controls

Little information is available regarding the transmission between the four engine unit and the single screw. Apparently the various engines transmit their power to one central shaft, carrying a single transmission gear wheel as shown in Fig 9.

Figure 10 shows the commodious pilot's cockpit with dual control, looking into the engine room.

At a speed of 120 kilometres there is a fuel capacity of 30 hours with a load of 2 pilots, mechanics and navigators with their luggage and accessary instruments. For commercial aviation the Linke-Hoffman R2 model is now provided with an enclosed cabin for 12 passengers aft of the pilot's cockpit

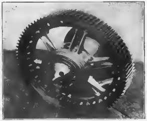


Fig 9 Single Gear Wheel of the Four Engines

Various advantages are claimed for the central power plant installation as compared with the interplane power plant installation, such as the absence of side obstructions for vision and gun range, the decrease in number of mechanics, since one mechanic can now take care of all four motors, a more complete understanding between engineers and pilots. The central power plant with single screw has a further advantage in simplicity over the twin screw type, and the few parts can be made rugged. The slow turning propeller can be made very efficient. There is almost complete reliability in the power system

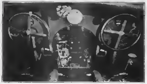


Fig 10. Pilot's Cock Pit Looking Into Engine Room

Book Review

How an Aeroplane is Built, by Stepney Blakeney 233 pages. Aeroplane and General Publishing Co London 5/— net

This book appeared originally as a series of articles in the *Aeroplane* Mr Grey, the writer of the introduction, states that Mr Baker has an intimate knowledge of detail work. We can thoroughly endorse this opinion

At first it might be thought that this was merely a descriptive book on the building of small airplane models, but as a matter of fact, it is a thoroughly practical and most comprehensive manual of airplane construction We might almost say it is the first work of its kind in the airplane field.

The author describes the most practical way of building longerons, struts, spars, gives detail instructions as to jigs, assembly, erecting and setting out The text is illustrated with the best kind of sketches

Wing covering and doping are treated somewhat sketchily but this is more than made up for by the careful remarks on metal parts and fittings.

A great many of the practical tips which it takes an airplane man years to learn are to be found in this little book.

Resume of Wind Tunnel Tests of Airship Envelopes

By J. C. Hunsaker, Eng. D.

A large number of stream line bodies have been tested in the 8-ft wind tunnel of the Washington Navy Yard, and without going into the details of these tests certain conclusions of general interest have been reached

The resistance in a relative wind of velocity V is expressed by the formula

$$R = C\, C/g\, (\text{Volume})^{2/3}\, V^2$$

when C/g is the density of the air and C a coefficient and nearly constant. The form having the lowest value of the coefficient C has the least resistance for given volume or buoyancy This expression was first proposed by Prandtl and is in general use

In the course of tests on various forms, the coefficient C has been found to vary with the speed of the wind or as the quantity VL as would be expected from dimensional theory. The resistance can only vary as V^2 when the resistance is caused by eddy making Good stream-line forms have a minimum of eddy making resistance and skin friction has a relatively large effect.

In fact, for seven models of very different shapes, representing seven actual dirigibles, the skin friction computed by Zahm's formula, .00000778L[illegible]V[illegible]b, amounts to from 79 to 73 per cent of the total resistance observed

The coefficient C appears to vary between V[illegible] to V[illegible].

The disk ratio or ratio of total resistance of model to its major circle varies between 15 and 17

The resistance as measured appears to vary not as V^2, but by a lower power Individual models show exponents between 1.85 to 1.92.

Yawing moments determined for several models indicates practically no differences for small angles. It appears to be immaterial what form of bow or stern is used within reasonable limits

The shape of the mid section has the most important effect on resistance. Bow and stern are less important A parallel middle body is disadvantageous, and for a length added equal to diameter may increase resistance 15 per cent

The form of bow is slightly more important than the stern. A pointed nose can be replaced by a rounded one of good shape without change in resistance. A long, fine or conical tail is much worse than a shorter, rounded one of easy curvature A fineness ratio between 5 and 6 appears more advantageous

The above notes apply only to good forms. The forms tested vary in resistance, depending on shape, not more than 8 per cent above or below the average of the series.

Hydro Boat Invented by Alexander Graham Bell Reported to Make 71 Miles per Hour. Liberty Engines
(C) *International*

HISPANO-SUIZA
Aeronautical
Engines
Manufactured by
Wright-Martin
Aircraft Corporation
New Brunswick, N. J.
LOWER HALF CRANKCASE
STUD ASSEMBLY

MAYNARD LOSES TO DONALDSON

TWO RECORDS ESTABLISHED

Captain Averages 108 Miles an Hour; Covered 823 Miles in Day.

Although Lieut. Belvin W. Maynard, the "flying parson," was the first aviator to fly from Mineola to California and return in the transcontinental aerial derby, an unofficial calculation of his flying time and that of other aviators eliminates him from first places in the race

It is estimated that Capt. J. O. Donaldson, second to return to Mineola, and the aviator who made the flight in an SE-5, a one man scout plane equipped with a 150 horsepower American built Hispano-Suiza motor, travelled twice across the country, a distance of 5,400 miles, in 45 hours, 56 minutes and 21 seconds. Lieut. Maynard's working time in the air was 50 hours, 13 minutes and 24 seconds. In reckoning his time, however, there must be added a period of eighteen hours in which he was on the ground between control stations changing his motor.

Capt. Donaldson, a veteran flier of the war, * * * * * * * * * * is credited with two world's records established in the flight: One for covering the 5,400 miles at an average speed of 108 miles an hour, and the other for making a single day's flight of 823 miles, accomplished last Saturday when he flew from Rock Island, Ill., to Binghamton, N. Y.

Engine Works Like Clock.

Besides these records Capt. Donaldson also has the distinction of being the only aviator to make the flight with the same motor, which was still in perfect working condition at the finish. The engine worked like a clock at all times, and it was not even necessary to change a spark plug. * *

EVENING SUN N.Y.
Oct. 22nd 1919

Air Fans for Driving Generators on Airplanes

By Capt. G. Francis Gray, U. S. A.; Lt. John W. Reed, U. S. A., and P. N. Elderkin

Engineering and Research Division, Radio Development Section, War Department, Washington, D. C.

In this paper the authors first briefly describe the method employed by the Radio Development Section of the War Department in testing air fans used for driving the electric generators usually installed on airplanes for radio communication. They next discuss at some length the various types of air fans used during the war and present numerous photographs and curves clearly illustrating the construction of the fans and their operating characteristics.

The difficulty of the problem lay in designing a fan which would turn at constant speed in the air streams of widely varying speed set up by the airplane in flight. The various types of fans tested were: Fixed-blade fans of special blade shape, fixed-blade fans with wind brakes centrifugally regulated, fixed-blade fans using a friction clutch or a friction brake centrifugally regulated, and pivoted-blade fans in which the pitch is centrifugally regulated.

During the war extensive use was made of radio telegraph and telephone apparatus on military airplanes, and the problem of power supply for such equipment received a great deal of attention. The possible sources of energy may be listed as follows:

a Storage batteries or dry batteries.

b Generators driven from the airplane engine, with or without floating storage batteries, and supplying the radio sets directly or through dynamotors.

c Generators driven by separate gasoline engines.

d Generators driven by air fans or "windmills" placed in the air stream outside the airplane fuselage.

From an economical point of view, method *b* is preferable. It was seriously considered, but since it involved cooperation between organizations normally operating independently its adoption was delayed. Meanwhile the practice in our army followed that of our Allies, principally the French, in the use of method d, mounting the generator outside the airplane fuselage and driving it with an air fan.

The work done on the development of air fans for this service was carried out by the Radio Development Section of the Signal Corps, and since it was done under the press of military necessity it was directed entirely by utilitarian considerations, was often fragmentary, and neglected investigations, the need of which was realized but for which time and personnel were not available. This record is presented with the work still in unfinished form in the hope that results obtained may be useful to those who may have occasion to carry out further investigations on the problem.

Conditions for Which the Air Fans Were Designed

Two sizes of generators were to be driven by the air fans it was desired to develop. The essential data on these are as follows:

	Generator for Radio Telegraph Sets.	Generator for Radio Telephone Sets
Generator diameter, in.	6¼	4 11/16
Generator output, watts	200	50
Required power from fan, watts	330	250
Normal speed, r.p.m.	4500	4000

Methods of Test

Practically all of the tests recorded in this paper were made with the wind tunnel of the Bureau of Standards, and the management and personnel of the Bureau aided materially in expediting them. A special testing generator was mounted in the wind tunnel and the fan to be tested was attached to it. This generator was provided with a magnetic tachometer, a separately excited field, and convenient means for applying load to the armature circuit. The external shape and size of the machine were made identical with those of the radio generators, with which the air fans were to operate in service, and with this generator and the regular wind-tunnel equipment for measuring wind velocity, tests could be made rapidly and accurately.

All of the air fans considered in this development have normal speeds of 4,000 r.p.m., or above, and the centrifugal forces are very considerable. It was therefore found necessary to provide an overspeed test to precede the wind tunnel test. For this purpose a 30-hp. motor operating through a 43-to-3 De Laval speed-increasing gear to a suitable shaft extension for the fan was set up. This device was capable of driving the air fans at speeds up to 14,000 r.p.m., and to prevent damage to gears or bearings in case of failure of the fan a "weakest point" was provided by a replaceable notched shaft extension. Failure at this point merely resulted in the breaking of the replaceable shaft extension and of course the destruction of the fan, without injury to bearings or gears. Heavy guards prevented the flying fragments from causing any damage. This equipment was designed by Capt. F. E. Pecsot, Officer in Charge of the Signal Corps Laboratories at the Bureau of Standards. There is one serious objection, however, to this method of over-speed testing in that it absorbs a large amount of power and puts abnormal thrust strains on the fans. A baffle to prevent air flow materially reduced this effect and later experience indicated that it would have been preferable to make the overspeed test in a very simple auxiliary wind tunnel with an aperture just large enough to drive the unloaded fans at the speed desired. Nevertheless, the apparatus just described was used in all tests discussed in this paper.

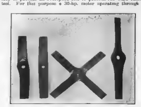


Fig 1. Pre-War Air Fans

In cases where the strength of a fan was problematical it was first given an overspeed test only slightly in excess of the running speed expected in the wind tunnel. After the wind tunnel test it was again tested to the required overspeed or to destruction. The best fans were required to withstand up to practically double normal speed.

Simple Non-Regulating Air Fans

As in all power plant problems, the ideal in this development was a constant-speed drive for the radio generator. When the development began the only air fans available were non-regulating wooden fans such as those illustrated in Fig 1. These fans have the characteristic that rotational speed is practically proportional to air speed, and when combined with the normal variations in the speed of the airplanes this fact leads to very severe requirements for the generator. As an example, a generator which would give satisfactory performance at 3,750 r.p.m. was required to withstand an overspeed test of 14,000 r.p.m. for mechanical performance and, with the addition of a very special regulating device, to hold its voltage within 15 per cent at speeds from 4,000 to 12,000 r.p.m.

Although the need for better air fans was obvious, the non-regulating types had to be used until others could be developed, and a considerable amount of work was done in adapting them to the particular requirements to be met. Fig 2 shows the construction of one of the final forms used with generators for radio-telephone sets, and Fig. 3 its performance in the wind tunnel. Figs. 4 and 5 give similar information on a larger size fixed blade fan used for radio-telegraph sets. Fig. 5 also gives an idea of the variation in individual fans supposed to be identical. Considerable trouble was experienced with these fans, due to the fact that the method for calculating air fans was assumed to be the same as that used for propellers.

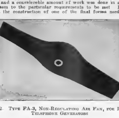


Fig 2. Type FA-3, Non-Regulating Air Fan, for Radio-Telephone Generators

Obviously it is desirable to establish the correct method of calculating these fans, but the pressure of more important work prevented its being undertaken by the Radio Development Section. The subject, however, was given much attention by Mr E. N. Fales, of the Airplane Engineering Department, Bureau of Aircraft Production of the Army, who assisted the Section very materially during the early stages of the development described in this paper, and it is hoped he will publish his conclusions.

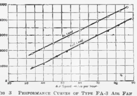


Fig 3. Performance Curves of Type FA-3 Air Fan (Diam. 15 in., pitch 2.1 ft.)

Regulating Air Fans

No one can work with simple air fans without being impressed with the desirability and apparent simplicity of modifying them so that instead of the straight-line relation between air speed and speed of rotation there will be more or less tendency toward constant rotational speed with varying air speed. Among the disadvantages which may be corrected by making the air fans self-regulating are the following:

a Undue head resistance.

b Excessive centrifugal stress in armature windings.

c Vibration.

d Commutator and bearing troubles.

e Troubles with voltage regulators.

f Troubles in radio sets due to varying voltage.

During the progress of this development a great many schemes for the construction of self-regulating fans were proposed. As all previous experiences led to the conclusion that the performance of a fan could not be predicted with any degree of accuracy, every reasonable suggestion was carefully considered and if possible tried out. Fundamentally all the fans tested may be classified under five principles of operations, as follows:

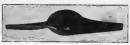


Fig. 4. Type FA-6 Non-Regulating Air Fan for Radio-Telegraph Generators

a Fixed blade fans of special blade shape.

b Fixed blade fans with wind brakes centrifugally regulated.

c Fixed-blade fans using a friction clutch centrifugally regulated.

d Fixed-blade fans using a friction blade centrifugally regulated.

e Pivoted-blade fans in which the pitch is centrifugally regulated.

Fixed-Blade Fans of Special Shape. Certain air fans submitted to the Signal Corps were supposed to give speed regulation on the principle that the angle of attack and efficiency can be made to alter with the wind velocity in such a way that the ratio of wind velocity to r.p.m. need not be constant. Tests were made first on a series of blade sections and later on a fan, shown at the right in Fig 1, which was said to possess the regulating features in a marked degree. The conclusion from these tests was that at no load the performance of properly designed fans tends to confirm the hopes of the designers, though the magnitude of the regulating effect is small, but under load, particularly varying load, it was impossible to distinguish any improvement over the ordinary fixed-blade types of fans. Consequently this method was discarded as of no practical value.

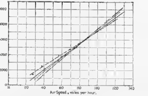


Fig 5. Performance Curves of Type FA-6 Air Fan (Diam., 20 in., pitch 1.75 ft.)

Fixed-Blade Fans with Wind Brakes. Fans of this type are

By courtesy of the American Society of Mechanical Engineers.

provided with wings, pins or other projections which are normally enclosed in a recess in the blade, but which are caused by centrifugal force to emerge and so retard the rotation of the fan. They have the disadvantage of low efficiency and consequent high head resistance, but were considered worth trying. Fig. 6 shows various development models.

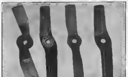


Fig. 6. Fixed-Blade Fans with Wind Brakes

Round rods, rods with cloth and metal wings, flat strips, etc., were tried for the moving brake element. Many showed practically no regulation of course, but others were reasonably promising. Among such was the type in which the brake arms were pivoted and moved out into the air by the action of centrifugal weights. Another interesting fan had the break arms actuated not by centrifugal force, but by the air pressure on a plate mounted in advance of the nose of the fan, and gave a curve in which, for a certain range, the r.p.m. actually decreased with increase in air velocity.

The net conclusion from this research was that the wind brake principle would give fairly good characteristics over a limited range of air speed, and with further refinement it might have been worth putting into production. However, that stage was never reached, due to the work on the pivoted blade type of fan described below.

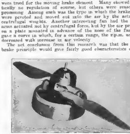


Fig. 7 Type FA-4-A, Variable-Pitch Air Fan

Friction-Clutch and Friction-Brake Fans. As in the types of regulating air fans discussed above, the friction-clutch and friction-brake principles of operation are inherently objectionable on account of their low efficiency and consequent high head resistance. They offered a possible solution, however, and were tried out experimentally. In the friction clutch type of fan the fan hub is capable of free rotation about the shaft of the generator, which it drives through a friction clutch. The clutch is released by the action of centrifugal weights when the speed passes the predetermined maximum, permitting the fan to run at higher speed than the driven shaft of the generator. The curve of this fan was satisfactory for the first model, but the heating due to slipping of the clutch at high velocities was too great to permit the use of the fan in practice and the development was abandoned.

In the friction-brake type of fan the fan is keyed to the generator shaft and is prevented from exceeding normal speed by a brakeshoe operated by a centrifugal weight and bearing on a plate attached to the generator frame. This also was tried and gave results essentially similar to those obtained with the clutch type. With the very considerable variation in air speed met with on airplanes, the friction devices generated so much heat that their use was impossible.

Variable-Pitch Air Fans. The ideal principle for the design of a regulating air fan is that of varying the pitch of the blades to correspond to the variation in air speed, this principle is by no means new, having been considered in a variety of forms for propellers for a number of years. The great difficulty in actual construction has been that the mechanical strength necessary to withstand the very high centrifugal forces and the delicacy of operation necessary for close regulation are very hard to combine.

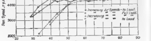


Fig. 8 Performance Curves of Type FA-4-A Air Fan
(Diam. 20 in., pitch variable)

This objection does not apply so forcibly to fans using very thin blades which are expected to warp under centrifugal action to change the pitch and a few samples which it was hoped would operate on this principle were tested. They were unsuccessful principally on account of mechanical construction and improved samples were never made up. The method is in any case of doubtful utility, since it can probably take care of only limited variations in speed, whereas the pivoted blade fans are capable of regulating over the widest variations in air speed likely to be met with in airplane practice.

Pivoted-Blade Air Fans. The earliest pivoted-blade fan to come to the attention of the Radio Development Section was made by the Sperry Gyroscope Company, but it proved unsuccessful, due to mechanical weakness. It was, however, the forerunner of very successful fans and serves to illustrate the general principle on which all operate. The blades are mounted on bearings and are capable of rotating through a considerable angle. Centrifugal weights are mounted on arms attached to these blades and tend to turn them to the proper direction to increase the pitch. A resisting spring and necessary hub complete the mechanism.

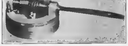


Fig. 9 Type FA-8 Variable-Pitch Air Fan, Single-Blade, 200-Watt

The first model to perform satisfactorily was designed by Mr. Thomas Slate, of the American Mechanical Improvement Company, of Washington, D. C. The very great improvement over the fixed-blade fans then in use made the production of this fan highly desirable, and it was undertaken at once under purchase specifications as follows:

Operating air-speed limits	40 to 300 m.p.h.
Normal speed	4500 r.p.m.
Speed variation less than	Plus or minus 4%.
Overspeed test	8000 r.p.m.

It was, of course, realized that this fan was by no means in its final form, and work toward improving it and providing new sources of production was carried on as rapidly as possible. One of the objections to the original design was that the particular mechanism used caused the centrifugal force to increase as the sine of twice the angle, while the spring restraining force increased according to a straight-line relation. In the second successful design this was corrected by the use of a special linkage between spring and blade, which modified the curve of spring resistance to fit that of the centrifugal weight. Fig. 7 shows one of these fans and Fig. 8 its performance. In this, as in many other cases of radio development work, the design was conceived and outlined by the Signal Corps engineers and the details worked out at once by the manufacturer (in this case the American Propeller and Manufacturing Company) in a form ready for immediate production.

The third successful design of variable-pitch air fan was the work of Mr. Pinaud, of the Des Lauriers Aircraft Corporation, and differs very radically from those previously described. It uses only one blade and its principal advantage is that by ingenious counterbalancing practically all strain is taken off the bearings, whereas in other forms the thrust bearings must carry a very considerable load—both radial and thrust—due to the high speed of rotation and the unbalanced designs of the blades. Friction, of course, results in considerable "lag" in the performance of the fan. The mechanical construction of the Pinaud fan is also a considerable improvement over its predecessors in simplicity and ease of manufacture. Figs. 9 and 10 show its construction and performance.

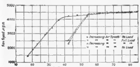


Fig. 10. Performance Curves of Type FA-8 Air Fan
(Swept diam., 20 in., pitch variable)

Head-Resistance Tests

A demonstration of the value of the regulating air fans in reducing head resistance was made by the direct test of a complete radio-telegraph transmitting set in the wind tunnel. A run was first made with the set equipped with a fan hub and nose cap, but no blades; then a second run was made with a fan operating normally with the generator both loaded and running light, and finally a third run was made with the fan blades locked at several values of pitch. The results of these tests are shown in Fig. 11, from which the following conclusions may be drawn:

The head resistance of the set fully loaded in an air stream of 75 miles per hour is 6.5 lb. At this air speed the resistance of the blades alone equals the resistance of the body, after which the resistance of the blades remain nearly constant, while that of the body increases as the square of the air speed. The body alone has 5 lb. head resistance at an air speed of 90 miles per hour, and at the usual ratio ⅛ h.p. from the engine per lb. of head resistance, this requires 0.36 h.p. from the engine. On a basis of 20 lb. in the fuselage per h.p. from the engine, the set would weigh 13 lb. more than it now does and still be no more load on the engine, provided it was mounted in the fuselage and obtained its power directly from the engine. This emphasizes the desirability already mentioned of obtaining all electric power by direct drive from the engine rather than from air fans where it is possible to do so.

Airfoil Tests on Blades for Regulating Air Fans

In designing blades for regulating air fans the effect of wind pressure in producing torque around the blade axis has been questioned, and obviously such an effect might seriously interfere with the performance of the fan. To obtain data on this point tests were made on blades from a fan of the type shown in Fig. 7, using an airfoil balance.

The results thus obtained show that this effect is negligible so far as practical designing is concerned.

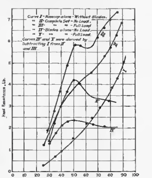


Fig. 11. Head-Resistance Curves, Type FA-4, Air Fan

The Fate of the R-38

On Oct. 22, in the House of Commons, Lieut.-Col. Moore-Brabazon asked whether Great Britain had made any arrangements with the American government for the building of a rigid airship in England for the United States Navy.

Major-General Seely, Under-Secretary of State for Air replied: Arrangements have been made between the United States Navy and the Air Ministry by which the Airship R-38 embodying the newest features in design and construction will be completed without delay. The vessel will be handed over to United States Naval personnel on completion, and will proceed to America with her American crew as soon as the shed to house her is ready.

French Practice in Airship Construction

Abstract by John Jay Ide, Lt. (j.g.), U. S. N. R. F.

Specification for Seams of Envelopes—Envelope fabric overlaps ½ in. at seams. Stitching is in two rows ¼ in. apart, seven or eight stitches to the inch The shuttle stitch is used

One single-ply fabric strip 1⅛ in wide of same color as exterior of envelope is cemented over exterior seam.

One single-ply raw white linen strip 1⅛ in. wide is cemented over interior seam. The strip is coated with unvulcanized rubber on the side next to seam. Over this is cemented another strip 1⅛ in. wide of single-ply fabric. This is rubberized on the gas side.

In kite balloons only one interior strip is used, but this is of 2-in width The envelope fabric overlaps ¼ in. instead of ½ in. The two rows of stitching, however, remain ¼ in apart

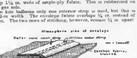


Fig. 1. Sketch of Seam

Each covering strip has its warp and weft, parallel and perpendicular, respectively, to its length, whereas the envelope has biased warp and weft (See Fig 1)

Precautions Taken Against Explosion When Filling Dirigibles—Following are instructions used for inflating airships

Do not allow pressure of balloon to drop below three-tenths of an inch (difference between the two levels of manometer)

After the hydrogen cylinders are connected to the balloon through copper tubes, manifold and inflation lead, observe the following order of operations to empty the cylinders First Open the valves on the manifold branches. Second. Open the main manifold valve Third Open the valves on the gas cylinders.

After cylinders are considered to be empty wait two minutes, and then First. Shut the main manifold valve Second Shut the valves on the manifold branches. Third Shut the valves on the gas cylinders Do not touch anything else

If the pressure drops below three-tenths of an inch, empty at first three cylinders If the pressure continues to fall, empty the other three cylinders.

The objects of the precautions taken in filling dirigibles are (*a*) Avoidance of combination of air and hydrogen to prevent explosive mixture and to avoid the reduced lift of gas mixed with air. (*b*) Elimination of fire hazard

These objects are attained by 1 General plant layout 2. Design of inflating lead and connections 3 Design of manifold and connections. 4. Procedure with dirigible envelope 5 Procedure with fabric inflating lead and connections. 6 Procedure with compressed hydrogen cylinders. 7 Electric lights and switches 8. Conduct of personnel 5 Fire-quenching means

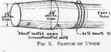


Fig 2. Sketch of Union

As to general layout there are two French schools of practice. In one the manifold is placed at a distance from the hangar, the fabric filling tube being from 150 to 300 ft long. The idea is that in case of fire at the manifold the fire may not reach the hangar and dirigible In the other school the filling tube is as short as possible, on the theory that with proper precautions fire hazard is eliminated and that a long filling tube is likely to take in more air (at connections, etc) than a short tube. In either case the manifold is placed outside the hangar

The fabric inflating lead is about 6 in. in diameter and very slightly bell-mouthed at the ends where attached to connections. Only one inflating lead is used. Unions are slightly tapered so that the flared mouths of the inflating lead fit over them snugly and are in tight contact with each union for a couple of inches of length (See Fig 2.)

The manifold, of the simplest possible type, is of solid cast brass or bronze with six branches. The inside diameter is about 0 8 in The dead end of the manifold should be solid, not a mechanical or welded joint The inflation tube end should have the slightly tapered shape described for unions. This end of the manifold is provided with a simple, but positive, main valve. Each of the six manifold branches and each hydrogen cylinder is provided with a valve smaller than that on the manifold but of similar design. Small, pliable copper tubes (0 16 to 0.2 in inside diameter) connect the manifold branches, through suitable unions, with the hydrogen cylinders

The envelope is flattened out as much as possible before inflation so that there is no residual air.

After the inflation tube has been connected up it is flattened as much as possible The tube should never be connected with a fold in it, as hydrogen would escape through the crevices (adding to the fire hazard), or air would be admitted by means of injector action and diffusion, lessening the lift of the dirigible (See Fig 3)

Prior to inflation, during a stoppage thereof, or after completion, the inflation tube is left connected, but should be tightly tied up at appendix and manifold

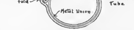


Fig 3. Sketch of Defecti. Connection

The hydrogen cylinder valves are never opened, except when attached to tubes connecting with manifold. If they were opened, the escaping hydrogen, expanding, would have a refrigerating effect, perhaps producing atmospheric electricity. It should be emphasized that when cylinders are empty their valves must be closed, and remain so to avoid presence of air on refill of cylinders.

The hangar is illuminated by incandescent electric lights protected against fire hazard in the most approved way. All switches and keys to the lights should be outside the main hangar hall, separated therefrom by a wall.

The usual precautions such as non-smoking, non-carriage of matches, etc., are observed by those working in the hangar. In addition, it is desirable that electric flashlights be turned on and off outside the hangar If not, the flashlight must be held in the pocket while being turned on and off

Open bags of dry sand are placed next to the inflation tube at its junction with the manifold and its entrance to the hangar. In case of fire or other accident the bag can be placed directly on the tube, thus flattening it and shutting off the gas flow, also dry sand is an excellent fire-quenching means.

Precautions Against Sparks from Atmospheric Electricity and Radio—All metal parts of the radio equipment are sep-

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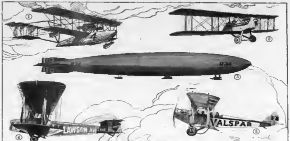

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3A The Valentine crew Valsparring the rear propeller of the R-34

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arated from the bag by a distance of from 3 to 6 ft., where attached to the bag they are suspended by cords of vegetable fiber giving such a gap

Metal parts used inside the balloon, as in valves, etc., are so designed that no intermittent contacts are made. There must be no gaps between metal parts across which an electric charge could be transferred The parts of metal hinges, for instance, must be in continuously good electrical contact, if they are in contact at all

These precautions are laid down by the constructor of the airship. Other precautions are prescribed by the radio authorities.

Suspended vs. Diaphragm Type of Ballonet—The latter type is preferable.

Objections to suspended type

(1) The ballonet tends to tear at point of suspension, therefore it must be made of heavier material than the diaphragm type.

(2) Repair of the ballonet is difficult, as its upper part cannot be reached by a man inside

(3) The suspension system tends to deform the top of the main envelope.

Advantages of diaphragm type

(1) There is no tendency to tear, therefore a light fabric may be used

(2) Repair is a simple matter

(3) There is no deformation of main envelope.

(4) There is less diffusion surface, hence less material and again a lighter ballonet.

(5) When empty, the thickness of two fabrics at the bottom of the envelope is interposed between the gas and atmosphere.

To prevent the shifting of the ballonet longitudinally a system of cord stays is used

In the case of long ballonets, transverse non-rubberized silk curtains perforated with 1-in holes are used. These curtains are attached at the top of the ballonet, but are free at the bottom. They do not impede the even distribution of air into all compartments of the ballonet on its change of volume, but they are effective in preventing surge of the air mass.

Sand vs. Water as Ballast—Water is preferable as ballast for the reason that sand is very likely to get into the motor and other apparatus, with a possibility of serious damage

To the objection that water may freeze, it may be replied that a great part of the time airships do not operate under conditions where this may take place If the airship does go into freezing weather or altitudes, wood alcohol or glycerine may be put into the water to lower its freezing point. Salt should never be used on account of destruction of fabric, etc.

Even sand, however, is preferable to lead or other solid ballast on account of damage done to the terrain by the latter. This, of course, does not apply to bombs as ballast when over enemy terrain.

Necessity for Independent Blower Unit—An independent blower unit is considered necessary for a small airship, as additional air may be needed when the balloon is drifting, when neither a main motor take-off nor a ventilator system can be used.

A 2 to 4 hp. gasoline blower engine is recommended for a small airship. In addition, there should be a ventilating funnel and tube, the flared mouth of which is just abaft the main propeller tip and preferably under the car

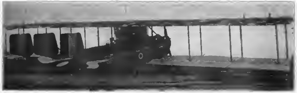
For an airship of about 250,000 cu. ft. the main power plant should be in two or four units. Each of these units should be provided with a take-off, clutch and blower, to insure reliability.—*Aircraft Technical Note Bureau of Construction and Repair, Navy Department*

Air Mail Record

All load-carrying air plane records for the postal mail service were broken on Dec 2 when a twin-motor De Haviland 4 plane devised by and manufactured for the Post Office Department, covered the distance between the air mail field at Washington and that at Belmont Park, New York—a distance of 218 miles in 1 hour, 34 minutes, with a mail load of nearly 30,000 letters weighing 630 pounds. The speed was at the rate of 138 miles an hour. The best previous record was on Sept. 19, when a single motor De Haviland carried 300 pounds of mail from Washington to New York at a speed of 123 miles per hour and the third best record was on October 1 when a Curtiss plane carried 348 pounds from New York to Washington at a speed of 118 miles per hour

The twin-motor De Haviland today was piloted by Samuel C. Eaton Jr., of Philadelphia, Pa., and left College Park at 11 A M. arriving at Belmont Park at 12.34 P. M. The time of flight included two circles around the field for altitude before setting out on his course and was the first trip made by the plane in a regular carrying of the mail This plane is perhaps the only twin-motored plane built in the United States which not only maintains the altitude under full load with one engine but actually climbs on one engine. In the opinion of the postal authorities it is the greatest forward step made in the development of a small weight-carrying plane. It eliminates the fire hazard by having the engines in the wings and away from the gasoline supplies and also it minimizes danger to the pilot for the same reason. The twin-motor De Haviland is a distinctive product of the postal service being outlined personally by the Second Assistant Postmaster General Otto Praeger The details of construction were worked out by Mr. A. H Flint, College Point, N Y

The plane will enable the Department to salvage several hundred thousands of dollars worth of De Haviland 4 war planes and parts as well as Liberty motors, the power plant being two six-cylinder Libertys of 200 hp. each which can be constructed almost entirely out of one 12-cylinder, 400 hp. Liberty The plane can carry nearly double the mail load that is carried by the single motor De Haviland.



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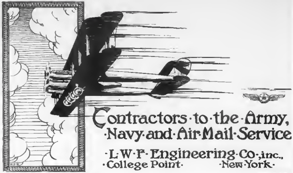

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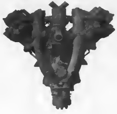

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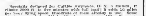

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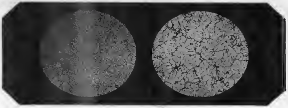

Micrograph of section of *Lynite* Piston, showing close-grained structure of metal.

Micrograph of section of piston made from same alloy but by sand-casting process.

The Camera Doesn't Lie

To the eye, two aluminum alloy pistons may look just about alike, but put them under the searching gaze of the microscope and surprising differences are likely to appear.

The illustrations above are micrographs of sections of two pistons, one made by the ordinary sand casting method, the other by the permanent mold process, used in making *Lynite* Pistons.

The same alloy was used in each case and the sand-cast piston is probably better than average, yet it takes but a glance to see how much finer the grain and more closely knit the structure of the permanent mold piston.

The finer grained structure is due to the rapid cooling during solidification which results in a better dispersion of the copper aluminum compound. This makes the piston wear much longer at every point, on the skirt, on the wrist-pin bosses and around the ring-grooves. Another operating advantage of *Lynite* Pistons is freedom from hard spots, eliminating danger of scratched cylinders.

Lynite Pistons also have a number of advantages in manufacturing. Less metal has to be removed in machining because they can be cast to closer dimensions. Freedom from hard spots makes possible greater machining speed because less trouble is encountered with dulled tools and, furthermore, fewer castings have to be rejected.

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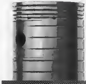

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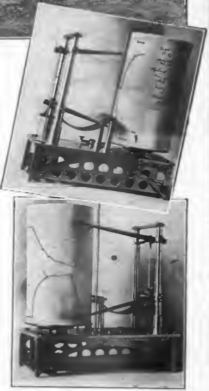

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